Chapter 10

Training Decision Makers for Complex Environments: Implications of the Naturalistic Decision Making Perspective*

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Perhaps the most significant contribution of the Naturalistic Decision Making (NDM) perspective is that it has forced researchers to reevaluate the assumptions they hold about how people make decisions in "real" environments (Orasanu & Connolly, 1993). A logical extension is to examine the *practical* implications of this theoretical perspective on decision making. In particular, it is of interest to determine how conclusions drawn from the NDM perspective affect the manner in which decision making might be optimized, or at least improved. Therefore, the purpose of this chapter is to examine NDM-related theorizing from the standpoint of what

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14. ABSTRACT
The purpose of this chapter is to examine Naturalistic Decision Making (NDM)-related theorizing from the standpoint of what it implies for how we train decision makers. It is based largely on the panel discussion (from the Second Naturalistic Decision Making conference held in Dayton OH in June 1994) devoted to this topic. This chapter focuses on generating propositions for training the cognitive aspects of decision making as suggested by the NDM perspective. Suggestions are offered for future research in this area.

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it implies for how we train decision makers. It is based largely on the panel discussion devoted to this topic; panelists included the authors, John Schmitt, Hugh Wood, Raanan Lipshitz, and Jon Fallesen.

Before proceeding, we have several important points to make regarding NDM and training, and more specifically, our approach in this chapter. First of all, it became clear from the panel discussion that panelists were not familiar with any empirical investigations of the effectiveness of NDM-generated training interventions. This conclusion was bolstered in an extensive literature search we conducted for the purpose of identifying studies conducted on this topic. Therefore, this chapter is necessarily analytical in nature. Specifically, it focuses on generating propositions for training the cognitive aspects of decision making as suggested by the NDM perspective. Furthermore, we do not attempt to review literature pertaining to this topic (this has been accomplished nicely by Means, Salas, Crandall, & Jacobs, 1993; Orasanu, 1993; and others); instead, we seek to organize and summarize thoughts on this topic.

We also note that the task of generating cognitive training principles consistent with NDM is not as straightforward as it may seem. In fact, the nature of NDM itself provides a significant dilemma when it comes to specifying training interventions because it is in conflict with the assumptions traditionally made about how people make decisions in the real world. According to NDM theories, effective decision making is not characterized by an invariant set of steps or procedures as prescribed by normative theories (Orasanu & Connolly, 1993). Instead, decision making is seen as intertwined with task accomplishment, context-specific, fluid, flexible, and in some respects, "procedure-free" (i.e., lacking prescribed rules as suggested in more classical views of decision making). These are seemingly impossible goals to achieve through traditional training—specifically, how do we train people to be flexible, or to engage in decision making that does not follow a set of predetermined steps?

Therefore, we have to reason about decision-making training, and particularly about what the goals of training might be, with a different point of departure under an NDM formulation as compared with classical decision-making perspectives (Means et al., 1993). In fact, the most fruitful way to characterize NDM-consistent training might be to view it as a mechanism to *support* natural decision-making processes, and as a means to *accelerate* proficiency or the development of expertise. The terms "managed experience," "augmented experience," and "accelerated proficiency" all come to mind as descriptive of the training philosophy that we believe is consistent with NDM theories. However, we also contend that knowledge, skills, and processes that underlie decision making—even naturalistic decision making—can be identified and trained. This is not to say that we can (or should) specify a single set of

steps for decision making, only that consistent processes that support expert decision making can be specified as a basis for training.

This position implies that we must be able to describe what expert decision makers *do*—delineate the knowledge, skills, and processes that may underlie effective decision making, and also describe the mechanisms of NDM that we seek to support. To accomplish this here, we first use NDM theories to establish a set of characteristics that describe expert decision makers (based on what are defined as the characteristics of "naturalistic" decisions). We then examine the processes, knowledge, and skills that NDM theories suggest are responsible for expert performance; in other words, *how* does the NDM perspective explain effective decision making performance? Next, we use this information as a basis to generate propositions regarding the manner in which training methods, strategies, and content might be designed in order to improve decision making. Finally, we offer suggestions for future research in this area.

CHARACTERISTICS OF EFFECTIVE DECISION MAKERS

One way to determine the implications of the NDM perspective for training is to address the question of what it suggests are the characteristics an effective decision maker. In order to answer this question, we first examine what we want trainees to be able to do at the conclusion of training. Once established, we can use these attributes as a basis to specify which knowledge, skills, and processes must be trained in order to achieve targeted performance.

As noted elsewhere, characteristics of the naturalistic environment (see Orasanu & Connolly, 1993) contribute to the requirements for effective decision makers. On this basis we hypothesize that effective decision makers can be described as:

1. Flexible—Naturalistic decision making contexts (that are ill-structured, dynamic, complex) require decision makers to be flexible. That is, decision makers must be able to cope with environments that are ambiguous, rapidly changing and complex. The implication of this line of thinking is that expert decision makers have a *repertoire* of decision making strategies that they can draw on in response to particular situational cues.
2. Quick—One of the characteristics of naturalistic decisions is time pressure (Orasanu & Connolly, 1993). This demands that decision makers are able to make rapid decisions, often in the face of severe consequences. It is also perhaps the single most important feature that

mitigates against analytical decision making (i.e., generating options, assessing options, etc.).

3. Resilient—Several of the characteristics noted by Orasanu and Connolly (1993) are indicative of stress in the decision-making environment. For example, ambiguity, uncertainty, and high stakes (i.e., severe consequences for error), along with other factors such as high workload and adverse physical conditions, are all stressors that can affect decision-making performance (Driskell & Salas, 1991). Therefore, in naturalistic environments, expert decision makers must be trained to operate under these conditions, without suffering degradations in performance (Means et al., 1993).

4. Adaptive—When events unfold rapidly in decision making, or decisions involve multiple goals, "static" models of decision making do not apply (Lipshitz, 1993). Instead, it is clear that a naturalistic view of decision makings suggests that decision makers must engage in a continual process of strategy assessment and modulation. This implies that decision makers must recognize when and how to apply a decision strategy and when to change, or modify that strategy in accordance with problem demands.

5. Risk taking—According to Orasanu (1993), expert decision makers in naturalistic settings have a tendency to use their knowledge more effectively to conduct risk assessment in making decisions. Obviously, when environments are characterized by high stakes, decision makers must- be able to assess the risk associated with various courses of action, and weigh the consequences of error against any potential payoff. This does not imply that decision makers generate multiple options or weigh them against each other; only that successful risk taking is often a crucial part of making decisions in naturalistic settings.

6. Accurate—To say that expert decision makers are accurate is stating the obvious. However, it is probably worth acknowledging that, particularly in light of the fact that many situations provide such high demand on the human decision maker, it is perhaps more surprising when costly incidents and accidents do not occur than when they do.

Now that we have established the characteristics of effective decision makers—essentially delineating a set of criteria that describe the "target" or goals of training—we can turn attention to examining what NDM-related theories have to say about how experts are able to perform as described earlier. The following subsections summarize what we know about the mechanisms of decision making—in particular, how experts are able to perform in the often difficult, challenging, time-compressed naturalistic environment.

MECHANISMS OF NDM AND EXPERTISE

As noted, the value of NDM theories in designing training lies in what they have to offer regarding the knowledge, skills, and processes that underlie expert performance. In addition, the study of expertise has yielded insight that has applicability to the naturalistic environment. Given these perspectives, we now highlight the following mechanisms of expert decision making that have been studied.

Situation-Assessment Skills

Several theorists operating under the NDM umbrella have argued that situation-assessment skills are paramount in effective decision making (e.g., see Klein, 1993; Orasanu & Connolly, 1993). According to Lipshitz (1993), all nine of the NDM-related theories he reviewed included an element of situation assessment, with several arguing that expert decision makers are able to perform situation assessment more quickly and accurately than novices. Overall, it is believed that this superiority in situation-assessment skills accounts for much of the ability of experts to make rapid decisions, and contributes to their decision-making accuracy. Two aspects of situation assessment behavior are:

1. Cue recognition/significance. For some time, researchers have believed that experts recognize decision-making cues differently than novices. For example, it has been concluded that experts recognize cues more quickly and completely than novices, recognize patterns of cues better than novices, and can detect important features of a stimulus more readily than novices (see Druckman & Bjork, 1991; Means et al., 1993). Experts also appear to be better able to frame decision problems so that they can detect the underlying structure of a problem (Orasanu, 1993). These skills all contribute to the decision maker's ability to perform effective situation assessment.
2. Pattern recognition. Several NDM theories place heavy emphasis on the ability of decision makers to perceive and recognize an entire pattern of relevant cues in assessing a decision making situation (e.g., see Klein, 1993). Experts are also believed to be able to "parse" the pattern of cues rapidly, ignoring those that are less relevant. According to Klein, it is this recognitional process that allows experienced decision makers to assess complex situations quickly.

Organized Knowledge Structures

One of the markers of expertise seems to be the organization of knowledge. That is, experts appear not only to know more, but also to organize knowledge more effectively (Druckman & Bjork, 1991). In terms specific

to NDM, experience allows experts to build up knowledge *templates* on which they can draw in new decision-making situations. This enables decisions to be made quickly (because the decision maker draws on preexisting memory structures) and contributes to the accuracy of decision making. Details regarding template building follow.

Template Building/Matching. Several NDM theories suggest that experts may store knowledge in templates, or as reference problems (Noble, 1993). For example, Noble contended that these reference problems contain objective features (i.e., the specific goals to be achieved by the decision maker), action features (i.e., a particular method for accomplishing the objective specified by the objective feature), and environmental features (i.e., criteria for adopting the solution method specified in the reference problem). Although this formulation is more detailed than others within the NDM perspective, many converge on the notion that over time, expert decision makers build well-organized knowledge structures that can be readily accessed and applied in decision-making situations.

Mental Simulation

NDM theories do not support the notion that decision makers generate and compare a series of response options; instead they assume that a recognitional process leads the decision maker to generate a solution from memory. However, when a situation is novel (i.e., a template for solving it does not exist in memory), mental simulation of the potential solution is hypothesized to be a primary mechanism by which a decision maker selects a course of action (Klein, 1993). According to Klein, this process allows the decision maker to determine whether the currently held solution is viable, and leads either to application or adjustment of the solution. It contributes to the accuracy of decision making, and helps decision makers to save time in crucial situations.

Strategy Selection/Modulation

As noted, flexibility is considered by many to be an important marker of expert decision makers. Several NDM theorists suggest that, in contrast to classical theories, no single set of decision-making processes can be delineated that describes the various types of decision making that occur in the natural environment (Lipshitz, 1993). Therefore, skilled decision makers must learn to select decision-making strategies that are best suited to the nature of the decision-making situation. Related to this, the fluid nature of many decision-making situations requires dynamic regulation of decision strategy. That is, decision makers must continually assess and modulate their

strategy in accordance with demands of the decision. One way that decision makers do this is via metacognition, a skill that contributes to a decision makers' flexibility, and ability to adapt his or her decision strategy when required.

Metacognition. Expert decision makers appear to be better able to monitor their own processes during decision making (e.g., Chi, Bassock, Lewis, Reimann, & Glaser, 1989; also see Druckman & Bjork, 1991). For example they are superior to novices in understanding their own level of comprehension, and what is necessary to improve their state of knowledge. This "executive" function is crucial in guiding a decision maker, particularly as the problem changes and evolves, because it allows the decision maker to adapt his or her strategy as needed. Orasanu (1990) maintained that effective metacognitive skills also allow decision makers to better manage resources because they have a more accurate picture of their own strengths and weaknesses, and of the nature of the problem.

Reasoning Skills

A host of skills that we refer to loosely as "reasoning skills" can be hypothesized to support NDM functions. In fact, the notion that expert decision makers must be flexible and adaptable suggests that several categories of reasoning skills may be useful in expert decision making. For example, Orasanu (1993) maintained that when problems are ill-defined, decision makers must be able to diagnose situations, which requires them to engage in causal reasoning, hypothesis generation, and hypothesis testing. Orasanu also noted that creative problem solving (i.e., constructing novel solutions to a problem, or applying existing strategies in a new or different way) is required when existing knowledge and procedures do not meet the needs of the current decision. Other reasoning skills include using analogies, critical thinking skills (i.e., testing assumptions, checking facts, seeking consistency among cues), and domain-specific problem-solving skills.

Domain-Specific Problem-Solving Skills. Obviously, experts have richer, more extensive domain knowledge than do novices. However, it is not only the knowledge content that distinguishes experts from novices, but also the manner in which decision strategies are applied to that knowledge (see Hoffman, 1991; Means et al., 1993). Specifically, experts use domain knowledge to determine when and how to apply various decision strategies (Glaser, 1984). This suggests that understanding general problem-solving skills will not improve decision-making performance—it is only in the

naturalistic context of a domain that decision-making strategies can aid performance.

IMPLICATIONS OF NDM THEORIES FOR TRAINING

As was stated at the outset of this chapter, we believe that the overriding goal of decision-making training according to NDM theory is to accelerate the natural processes leading to expertise. Now that we have examined those processes more closely, and briefly described relevant assumptions from research on expertise, it is possible to begin generating hypotheses about how NDM-consistent decision-making training might be designed. In addressing this issue we distinguish two types of propositions for training. The first involves NDM-derived suggestions for *what* should be trained—that is, the content of training. The second concerns implications from NDM theories regarding *how* decision makers should be trained—that is, the context, methods, strategies, and media employed in training. These categories of implications are presented in detail in the following sections.

Implications for What to Train Decision Makers

In considering what to train decision makers, NDM theories imply strongly that context-specific domain knowledge is a crucial aspect of expert decision making. In addition, there are several cognitive *processes* and *skills* that appear to be required for effective decision making (which are generated directly from the list of characteristics and mechanisms delineated previously) that should be trained. These include: (a) *metacognitive skills* (including the ability to select decision-making strategies, to modulate strategies as problems unfold, to engage in effective resource management, and to self-assess and adjust as necessary); (b) *reasoning skills* (including analogical reasoning, causal reasoning, creative problem solving, and critical thinking); (c) *domain-specific problem-solving skills* (although training "generic" problem solving strategies does not appear to be fruitful, training decision makers in problem solving specific to the domain may be more successful); (d) *mental simulation skills* (including the ability to know when to apply mental simulation as a means to evaluate a potential solution); (e) *risk assessment skills* (i.e., accurately assessing the risk associated with various courses of action); and (f) *situation assessment skills* (including the ability to make rapid, accurate assessments of the decision situation by improving pattern recognition skills and learning to assess the significance of such cues).

In addition, *knowledge organization*—fostering the organization of knowledge to support NDM—is an important training goal. Specifically, the

decision maker must be exposed to the "typical" situations, cues, cue patterns, and responses that characterize a domain. This process is crucial as a means to foster development of necessary decision-making templates in memory.

Implications of NDM Research for How to Train Decision Makers

NDM theories provide a number of implications for how decision-making training should be conducted. We are particularly interested in proposing training strategies that we believe can help accelerate the acquisition of proficiency or the achievement of expertise—that is, to aid decision makers in learning and organizing domain knowledge in a manner that supports complex decision making.

Simulations. Several researchers have noted the importance of simulation in training NDM skills (e.g., see Means et al., 1993). Simulation is a valuable tool for training NDM skills because it can accelerate proficiency by exposing decision makers to the kinds of situations they are likely to confront in the real world. Moreover, simulation can be controlled—the characteristics of decision problems, situational cues and cue patterns, and decision outcomes can be provided as a means to aid in development of situation awareness, pattern recognition, and template building. For this reason, scenario/exercise design becomes a crucial aspect of simulation-based training. In fact, the effectiveness of this type of training will depend largely on the extent to which scenarios capture and display important cues (and the relationship among them) along with associated responses, so that necessary templates can be developed. Simulations are also an effective means to train reasoning skills, metacognitive skills, and risk-assessment skills.

Guided Practice and Feedback. Several studies have shown that allowing trainees to practice on a task without feedback may produce suboptimal decision-making performance (Means et al., 1993). In the current context, we contend that it is crucial to provide feedback as a means to reinforce important "cue → strategy" associations. In this manner, guided practice (i.e., practice that incorporates measures of performance and specific feedback) can be thought of as managed experience—providing decision makers with examples that enable them to characterize cue patterns, build templates, and associate effective responses to cues and cue patterns.

Embedded Training. NDM theories generally suggest that decision making cannot be removed meaningfully from the context in which it occurs. This implies that training decision makers in the environment in which they operate is recommended if possible. One way to accomplish this is through

embedded or organic training. In such cases, training is incorporated into the operational system or equipment so that training takes place on the job (with appropriate safeguards). The success of such systems depends on their ability to support the development of expertise via performance measurement, specific feedback, and exposure to important decision cues. Therefore, scenarios and exercises should be developed that allow decision makers to build templates that represent a broad base of problems they are likely to encounter in their actual decision environment.

Cognitive Apprenticeships. Recently, another on-the-job training technique that has gained attention is cognitive apprenticeship (see Druckman & Bjork, 1991). Like traditional apprenticeships, which train skilled physical performance, cognitive apprenticeships allow the trainee to operate in his or her actual context, and require the trainee to work closely with an expert. Briefly, the overriding goal of this type of training is first for the expert to demonstrate effective performance, and then gradually to lead the student through a series of constructive activities that allow him or her to deepen, clarify, integrate, and synthesize knowledge. As such, it may be a useful means to train all of the skills noted earlier.

Multi-Media Presentation Formats. Investigation into the manner in which knowledge presentation formats affect knowledge organization and template building is needed. Initial evidence suggests that employing graphics and animation may aid in mental model development (e.g., White, 1984) and hence, may also have a positive impact on NDM processes. The impact of textual, graphic, animated, video, and audio presentation of knowledge on decision-making performance has the potential to provide important guidelines for training system designers.

CONCLUSIONS AND FUTURE RESEARCH

In this chapter we have attempted to provide ideas generated from an NDM perspective for training decision makers. At the risk of bemoaning the point, *our strong recommendation is that empirical assessments of NDM-generated training be conducted.* Until such studies are completed, we will only be able to generate theoretically derived propositions, as was done here. In closing, we offer a number of specific research issues that we believe require further consideration as a basis to design training:

1. On what basis do decision makers perceive similarity in situations? That is, what triggers the activation of a template in memory, or causes a

decision maker to seek additional information (or engage in mental simulation) when he or she does not perceive the template to match sufficiently?

2. In what manner might NDM-consistent training be incorporated into more traditional training environments? For example, given that decision making is not easily removed from its context, how might NDM training be integrated into other aspects of task training in classroom situations, simulations, on the job, or any combination thereof.

3. In knowledge-rich environments—that is, those that require a decision maker to hold and access a large volume of knowledge in making a decision—how should expert knowledge be organized so that it fosters access of necessary information in decision making? That is, how can we initially present knowledge in a manner that fosters development of templates that are accessible, flexible, complete, and useful?

4. What does the NDM perspective suggest for the manner in which we evaluate decision making? For example, how do we know when someone becomes an expert? What are the descriptors or criteria associated with expertise? What do we mean by proficiency? What are appropriate assessment strategies for decisions made under conditions that are dynamic, rapidly changing, and fluid?

In summary, NDM theories offer a rich and exciting basis on which to specify training that will improve decision-making performance. As such, it has the potential to contribute both to the science and practice of training (Cannon-Bowers, Tannenbaum, Salas, & Converse, 1991).

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